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THE PREVALENCE OF MAXILLARY ALTERED PASSIVE ERUPTION IN A  
DENTAL SCHOOL POPULATION

A thesis submitted in partial fulfillment of the requirements for the degree of Master of  
Science in Dentistry at Virginia Commonwealth University.

by

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# Abstract

## THE PREVALENCE OF MAXILLARY ALTERED PASSIVE ERUPTION IN A DENTAL SCHOOL POPULATION

By Francisco T. Carlos, D.M.D.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of  
Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, 2010

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Program director, Department of Periodontics, Virginia Commonwealth University

**AIM:** The aim of this investigation is to determine the prevalence of maxillary altered passive eruption in a dental school population. **METHODS:** 100 subjects were examined clinically and had models fabricated of their maxilla. Demographic, periodontal, cast measurements were recorded for each subject. Demographic variables recorded included age, gender, and ethnicity, history of orthodontic treatment, presence of incisal /occlusal wear, appearance of gingival excess, and presence of gingival asymmetry. Measurements made on cast included clinical crown length, clinical crown width, papillary height, and distance from the lateral gingival zenith to the gingival aesthetic line. Clinical

crown width-to-length ratio was calculated. These measurements were compared to previously published standards. **RESULTS:** 83% of the subjects had central incisors with a clinical W:L ratio greater than .80. Logistical regression analysis determined that subjects with central incisors with an appearance of gingival excess were more likely to have a clinical W:L ratio greater than .80 ( $P<.0007$ ; OR=79). ANOVA demonstrated that clinical crown length had a statistically significant relationship with gender ( $P<.0001$ ), tooth type ( $P<.0001$ ) and biotype ( $P<0.0026$ ). Clinical crown width and clinical crown W:L ratio had a statistically significant relationship with gender ( $P<0.0007$ ,  $P<.0001$ ) and tooth type ( $P<0.0026$ ,  $P<.0001$ ). The average clinical crown length was 0.5-1.5 mm shorter than established ideal measurements. **CONCLUSION:** 83% of the subject population had central incisors that displayed altered passive eruption. Subjects who exceeded the clinical W:L ratio of .80 were more likely to have been classified as having the appearance of gingival excess or “gummy smile”. Esthetic crown lengthening should be considered to achieve desired esthetics in these subjects.

This document was created in Microsoft Word 2007.

## Introduction

Esthetics is considered to be an important part of successful dental treatment, especially in treatment involving a patient's smile. An earlier study suggested that there are tooth shapes and sizes considered to be ideal<sup>1</sup>. Waldrop reviewed the essentials of an esthetic smile and divided the smile into an extraoral portion and an intraoral portion<sup>2</sup>. The extraoral portion of an esthetic smile includes the "frame" of the smile, which is made up of the surrounding facial features such as total facial symmetry or asymmetry, the plane of the eyes, position of the nose to the chin, the total amount of "lip rise" and the distance and symmetry between the commissures.

The intraoral portion is the infrastructure of the smile and is divided into three components.

The first component is the foundation and consists of the patient's gingival biotype, width of the periodontal attachment apparatus (biologic width) and alveolar bone thickness. The patient's biotype, defined as the bucco-lingual thickness of gingiva<sup>3</sup>, is important.

Different biotypes respond differently to surgical insult, orthodontic movements, and inflammation<sup>4</sup>. Gargulio<sup>5</sup> defined biologic width as the dimensional width of the dentogingival junction (epithelial attachment and connective tissue) which averages 2.04 mm. When including the gingival sulcus, the biologic width averages 2.73 mm. Bone thickness in a facial-lingual direction is vital because it provides stability to the gingival margin, may prevent formation of dehiscence during orthodontic movements, and can be a



barrier against future gingival recession. In the case of altered passive eruption, the alveolar bone crest may be at or near the cemento-enamel junction (CEJ). This can cause the epithelial attachment to lie on enamel, resulting in a coronal position of the attachment apparatus and the appearance of a “gummy smile”. A thick biotype can also contribute to the appearance of a “gummy smile”, according to a survey conducted by dental professionals on the perception of maxillary anterior esthetics<sup>6</sup>.

The second component of the infrastructure of the smile is made up of tooth length, width, and contact. The clinical-to-anatomic crown ratio should be 1:1, or entire anatomic crown exposure for ideal esthetics. There are established anatomical average sizes of maxillary central incisor to maxillary second premolar as reported by Wheeler<sup>7</sup>. However, these measurements were made on extracted teeth and many times the clinician does not account for the average length of gingiva covering the anatomic crown. Loe and Ainamo<sup>8</sup> described normal gingival attachment being an average of 0.5 to 2 mm. Subtracting 2 mm from the anatomic length gives a clinical crown value for central incisors, lateral incisors, canines, 1<sup>st</sup> premolars, and 2<sup>nd</sup> premolars of 8.5, 7, 8, 6.5, and 6.5 mm, respectively. These values can be used as a general reference, but desired clinical crown length is determined by location of the CEJ and subjective preferences of the patient and dental practitioner.

Previous research to define esthetic ideals used mathematic proportions described by the ancient Greeks<sup>9,10</sup>. The golden proportion is based on the theory that there is a relationship between beauty and nature in mathematics<sup>11</sup>. Levin<sup>9</sup> applied the golden proportion to the

smile, stating that the width of the maxillary lateral incisor should be in golden proportion to the width of the maxillary central incisor. The lateral incisor should be 62% of the width of the central incisor, and the canine should be 62% of the width of the lateral incisor. Lombardi<sup>10</sup> proposed the repeated ratio, which meant that the existing proportion between the width of the central incisor and lateral incisor should be consistent (progressing anteriorly to posteriorly). In a recent survey by Ward<sup>12</sup>, 57% of the dentists surveyed preferred smiles with the 70% recurring esthetic dental (RED) proportion. Ward<sup>12</sup> proposed the RED proportions for creating a proportional smile because the previously mentioned ratios did not compensate for body proportions, body types, or clinical crown tooth-length displays of the maxillary central incisors. The RED proportions state that the proportion of the successive widths of the maxillary teeth as viewed from the front should remain constant, progressing distally. When using the 70% RED proportion the width of the maxillary lateral incisor is 70% of the frontal view of the central incisor, and the canine is 70% of the width of the lateral incisor. The preferred width-to-height ratio determined in his study was .78, with an acceptable range of .66 to .80. More specifically, he found that the anterior maxillary crown width relationships should exhibit a ratio of 70% versus the Golden Proportion (62%). According to Gillen<sup>13</sup> these values hold true regardless of race and gender. Touati<sup>14</sup> et al. suggested that each anterior maxillary tooth plays a specific esthetic role, i.e. central incisors provide stability and balance, laterals provide charm, and canines bring strength into the esthetic zone. Interdental contacts should not extend below the gingival margin which can result in shortened and unaesthetic papilla.

The third component of the infrastructure of an esthetic smile is composed of the attached gingiva, free gingival margin, and interdental papillae. The attached gingiva should be pink in color, uniform in contour with natural pigmentation and stipples. Gingival inflammation should be absent and the facial gingival margin must end in a knife edge located 0.5 to 2 mm coronal to the CEJ. The gingival scallop follows the CEJ in health, with its apex located at the junction of the middle and gingival third of the crown for the central incisor. Ahmad<sup>15</sup> described the gingival esthetic line (GAL), or the line that connects the apices of the gingival scallop for maxillary anterior teeth. The author concluded that there should be symmetry in the gingival composition as it relates to this line. Ideally, the distance to the GAL in canines and central incisors should be the same length and the lateral incisor distance 1-2 mm shorter. The most apical part of the gingival scallop (gingival zenith)<sup>16</sup> should reflect the angle of the long axis of the tooth, and the papilla should measure 4.5-5 mm from the papilla tip to the depth of the marginal scallop<sup>17</sup>. Chu and coworkers<sup>18</sup> demonstrated that, in a population of 20 patients, all central incisors displayed a distal gingival zenith (mean of 1 mm) from the vertical bisected midline, lateral incisors showed a distal gingival zenith deviation of 0.4 mm, and 97.5% of canines had a gingival zenith centralized along the long axis of the tooth. Another criterion for esthetics is that the gingival papillae should fill the entire embrasure. There are two key measurements for ensuring papilla fill in the embrasure: interradicular distance between teeth and bone crest to contact distance. According to a study by Tarnow<sup>19</sup>, if the alveolar crest to contact distance is 5 mm or less, papillae will fill the embrasure 100% of the time. If the distance increases to 6 and 7 mm, papillae fill decreases to 56% and 27% of the time,

respectively. However, if the distance between roots is greater than 2.4 mm, the bone to contact measurement loses its influence<sup>20</sup>.

There are certain conditions involving the gingival complex that can lead to a deviation of normal values and compromised esthetics. One of these conditions is called altered passive eruption. Weinberg and Eskow<sup>21</sup> noted that teeth erupt in two stages consisting of an active eruption phase and a passive eruption phase. Moss-Salentign and Klyvert<sup>22</sup> defined *active eruption* as the physical movement of the tooth from its pre-functional subgingival position through gingival tissue into the oral cavity and finally into functional occlusion. *Passive eruption*, as defined by Gottlieb and Orban<sup>23</sup>, is the continual apical movement of the free gingival margin epithelial attachment or junctional epithelium and connective tissue attachment that occurs after the tooth reaches functional occlusion. Altered passive eruption has been defined as “failure of the tissue to adequately recede to a level apical to the cervical convexity of the crown” and as “the tissue’s failure to reach the CEJ”<sup>24</sup>. Altered passive eruption may be classified as delayed or arrested. In delayed altered passive eruption a normal biologic width is established while in arrested altered passive eruption there is minimal connective tissue attachment and the junctional epithelium is located on enamel.

Related to altered passive eruption is the amount of keratinized gingiva that is shown when smiling. This appearance of excessive tissue can cause teeth to appear square rather than a more pleasing ovoid or elliptical shape and it may cause a person to seem to have a high

lip-line when in fact it is a low to medium lip-line<sup>25</sup>. When considering optimal gingival display in the ideal smile, Kokich and coworkers<sup>26</sup> surveyed laypeople and discovered that they considered up to 3 mm of gingival display acceptable before esthetics were compromised.

There have been conflicting reports with regards to the prevalence of altered passive eruption and the relationship between age and the completion of eruption. Some authors believe that eruption of maxillary central incisors and canines was completed by age 12 years, with some changes in marginal gingiva of maxillary lateral incisors up to age 16<sup>27</sup>. Other studies conclude that passive eruption may continue up to age 19<sup>28</sup>. Volchansky and Cleton-Jones<sup>29</sup> reported that 12.1% of patients, with a mean age of 24.2 years +/- 6.2 years had altered passive eruption. The occurrence was 7% in men and 14% in women. This study was limited to a South African population. In a post-orthodontic population, Konikoff and Johnson<sup>1</sup> concluded that altered passive eruption ranged from 61-71%, meaning that these subjects had clinical width-to-length ratios exceeding the accepted ideal values. These results were seen mostly in a younger population. Previous research established that tooth length, width, and gingival position changes from childhood into adulthood. This presents an interesting question: What is the prevalence of altered passive eruption in a young adult population, if ideal width: length ratio of .66-.80? Another way of phrasing this question is: What prevalence of the population exceeds a width: length ratio of > .80?

The main purpose of this investigation was to (i) report the percentage of teeth (by tooth type) above the maximum ideal ratio of .80 (ii) report the average clinical length, clinical width, and clinical width: length ratio per tooth type and compare the results to accepted anatomical measurements (iii) calculate the influence of subject variables on clinical length, clinical width, and clinical width: length ratio measurements (iv) and evaluate whether the occurrence of a width: length ratio above .80 relates to other subject variables. A secondary purpose of this article was to report average papillary height per tooth type and the average distance of the lateral incisor gingival zenith to the gingival aesthetic line, and compare the results to measurements in previous studies.

## **Methods and Materials**

One hundred healthy, non-smoking adult subjects were randomly recruited from the Virginia Commonwealth University (VCU) School of Dentistry from August 2009 to April 2010. All subjects were enrolled either in the dental program or the dental hygiene program. All subjects were informed of the nature of the study and gave their written consent. Informed consent was obtained under a procedure approved by the Institutional Review Board for research involving humans.

The inclusion criteria for the study were that the patient have maxillary central incisors to 2<sup>nd</sup> premolars, that selected teeth must have contacts on both left and right side and that the patient be 18 years or older. Exclusion criteria included current pregnancy, active periodontal disease defined as bleeding on probing with clinical attachment loss of 4 mm or greater, systemic conditions that could modify the progression or treatment of periodontal disease, active orthodontic treatment, periodontal treatment within the last 6 months, missing teeth in recorded areas, history of drug use that could contribute to gingival overgrowth (anticonvulsants, calcium channel blockers, immunosuppressants) poor oral hygiene (i.e. evidence of gross supragingival plaque and calculus) and/or being a current or past smoker (defined as 10 cigarettes or more per day).

### *Periodontal examinations*

Clinical examinations were carried out by a single periodontal clinician (FC) in the VCU Clinical Research Unit. Patients' self reported age, gender, and race were recorded. Periodontal conditions measured included sulcus depth (SD) on 3 facial sites per tooth, Gingival Index (GI)<sup>30</sup>, Plaque Index (PI)<sup>31</sup> Clinical Attachment Levels (CAL), and Bleeding on Probing (BOP). An average SD, GI, PI, CAL and BOP was calculated for the subject population for each tooth type, second premolar to second premolar. Other clinical measurements recorded on the data collection sheet included positive or negative history of orthodontic treatment, presence or absence of parafunctional habits, presence or absence of incisal/occlusal wear, and subjective appearance or absence of gingival excess. Gingival biotype was described as "thick" when the subject had thick-flat gingival morphology, and "thin" when the subject had a thin-scalloped morphology. Gingival symmetry was described as symmetrical if the gingival aesthetic line (GAL) of the maxillary right and left sides were on the same plane, and asymmetrical if the right and left GALs were not on the same plane.

### *Cast Measurements*

All subjects had impressions of their maxillary arch taken with alginate, plaster models were fabricated, and measurements were taken with a digital caliper (Tresna® Point Digital Calipers #SC02) from teeth #4 to #13 on plaster models. Clinical crown length was recorded as the distance from the free gingival margin (FGM) to incisal or occlusal edge. This measurement was recorded as an average per tooth type and compared to ideal crown length values, as done in a previous study<sup>1</sup>. Clinical crown width was recorded as the



distance from mesial height of contour to the distal height of contour. This measurement was recorded as an average per tooth type and compared to average crown width values. Papillary height (PH) was recorded as the average distance from the gingival zenith to the mesial papilla tip of each tooth type and compared to an ideal papillary height of 4.5-5 mm based on previous research<sup>17</sup>. Lateral incisor relationship to GAL was recorded as the average distance from the gingival scallop of each lateral incisor to the GAL, and then compared to an ideal<sup>16</sup>. Clinical crown width-to-length ratio (W:L) was calculated from the average clinical crown length and average clinical crown width measurements of each tooth type. These measurements were compared to an ideal of .66-.80 width-to-length ratio as previously reported by Konikoff et al<sup>1</sup>. Any measurement > .80 was considered to have altered passive eruption. This data were compiled to give a percentage for altered passive eruption per tooth type. No assessment of the reproducibility of the measurements was performed.

### *Clinical Photographs*

Clinical photos of each patient was taken for future analysis. This consisted of a set of 5 photos per patient taken at a calibrated distance of 20 inches, which included, a photo of teeth #4-6, a photo of teeth #7-10, a photos of teeth #11-13, a smile profile photo and a smile “close-up” photo (canine through canine only).

### *Analysis*

The influence of race, age, biotype, and appearance of gingival symmetry, occlusal /incisal wear, parafunctional habits, history of orthodontic treatment, gender, and tooth type on

clinical length, clinical width and clinical W: L ratio was tested by using analysis of variance (ANOVA) with a mixed model that included a random effect for the subject. In addition, the effect of each parameter was measured within each subject and between subjects.

Logistic regression analysis was performed to predict the probability of the occurrence of a clinical W: L ratio greater than .80 and .90 when related to biotype, gingival symmetry, appearance of gingival excess, presence of incisal/occlusal wear, and history of orthodontic therapy. Odds ratios were calculated for central incisor, lateral incisor, and canine in order to assess the strength of association between these variables and a ratio of .80 or .90.

## Results

One hundred casts from a dental school population were measured according to the methods described earlier. The mean age of the subject population was 25.91 years old, with a range of 20-38 years of age. There were 39 females and 61 males. The ethnicity of the subject population was 72% Caucasian, 16% Asian, 6% Other, 4% Hispanic, 2% African American. Sixty-one (61) percent of the subjects had undergone orthodontic treatment, 67% had a history of parafunctional habits, and 95% had evidence of incisal/occlusal wear. Seventy-one (71) percent of the subjects had a thick biotype and 29% had a thin biotype. Ninety-three (93) percent were recorded as having a symmetrical appearing smile (**Table 1**).

For periodontal indices, the mean PI was 0.37 for 2<sup>nd</sup> premolars, 0.58 for 1<sup>st</sup> premolars, 0.82 for canines, 0.78 for lateral incisors, and 0.86 for central incisors. Mean GI was 0.23 for 2<sup>nd</sup> premolars, 0.35 for 1<sup>st</sup> premolars, 0.54 for canines, 0.61 for lateral incisors, and 0.58 for central incisors. Mean BOP was 2% of 2<sup>nd</sup> premolars, 3% of 1<sup>st</sup> premolars, 2% of canines, 2% of lateral incisors, and 2% for central incisors. (**Table 2**)

For tooth measurements taken on casts, the mean clinical width (mm) was 6.42 for 2<sup>nd</sup> premolars, 6.81 for 1<sup>st</sup> premolars, 7.69 for canines, 6.66 for lateral incisors, and 8.53 for

central incisors. Mean clinical length (mm) was 6.99 for 2<sup>nd</sup> premolars, 8.08 for 1<sup>st</sup> premolars, 9.44 for canines, 8.27 for lateral incisors, and 9.79 for central incisors. Mean W:L was 0.93 for 2<sup>nd</sup> premolars, 0.85 for 1<sup>st</sup> premolars, 0.82 for canines, 0.81 for lateral incisors, and 0.88 for central incisors. Mean PH was 3.70 for 2<sup>nd</sup> premolars, 3.94 for 1<sup>st</sup> premolars, 4.38 for canines, 3.88 for lateral incisors, and 4.60 for central incisors. The mean clinical W:L was then compared to the ideal clinical W:L of .66- 80%. For 2<sup>nd</sup> premolars, 89% were greater than .80 W:L; 1<sup>st</sup> premolars, 71% were greater than .80 W:L; canines, 59% were greater than .80 W:L; lateral incisors, 54% were greater than .80 W:L; central incisors, 83% were greater than .80 W:L. The average distance (mm) from the gingival zenith of #7 and #10 to the GAL was 1.05 and 1.08, respectively (**Tables 3 and 4**).

Of the parameters examined, a statistically significant relationship was found between clinical tooth length and biotype ( $P<.0026$ ), gender ( $P<.0001$ ), and tooth type ( $P<.0001$ ). The mean clinical tooth length for subjects with thick biotype was 8.31 mm versus 8.75 mm for subjects with thin biotype. The average tooth length for females was 8.12 versus 8.93 mm for males. Average clinical length by tooth type is reported (**Table 5**), with central incisors > cuspids > lateral incisors > 1<sup>st</sup> premolars > 2<sup>nd</sup> premolars. ANOVA failed to show any statistically significant association with relation to race, age, appearance of symmetry, occlusal/incisal wear, parafunctional habits, and history of orthodontic treatment.

With regards to clinical tooth width, a statistically significant relationship was found between gender ( $P<.0007$ ) and tooth type ( $P<.0001$ ). In females, average tooth width was 7.34 mm versus 7.64 mm in males. Average width per tooth type is reported (**Table 5**), with central incisors > cuspids > lateral incisors > 1<sup>st</sup> premolars > 2<sup>nd</sup> premolars. ANOVA failed to show any statistically significant difference with relation to race, age, biotype, appearance of symmetry, occlusal /incisal wear, parafunctional habits, and history of orthodontic treatment.

When examining clinical W:L ratio, a statistically significant relationship was found between gender ( $P<.0026$ ) and tooth type ( $P<.0001$ ). Average clinical W:L ratio was .92 for females, and .87 for males. Average clinical W:L ratio per tooth is reported (**Table 3**), with 2<sup>nd</sup> premolars > central incisors > 1<sup>st</sup> premolars > canines > lateral incisors. ANOVA failed to show any statistically significant relationships with race, age, biotype, appearance of symmetry, occlusal/incisal wear, parafunctional habits, and history of orthodontic treatment.

Results from the logistic regression analysis suggested that the subjective appearance of maxillary gingival excess is related to whether the clinical W:L ratio exceeded .80 and .90 for the maxillary central incisors, lateral incisors, and canines. The central incisors ( $P<0.0007$ ), lateral incisors ( $P<.0001$ ), and canines ( $P<.0001$ ) demonstrated that there was a statistically significant relationship between subjective appearance of gingival excess and a ratio above .80. There was a lack of significance when relating biotype, gingival

symmetry, history of occlusal wear, and history of orthodontic treatment to a ratio above .80.

The central incisors ( $P<.0001$ ), lateral incisors ( $P<.001$ ), and canines ( $P<.0001$ ) also demonstrated statistical significance when relating appearance of gingival excess to a ratio of .90 or above. There was a lack of significance when relating biotype, gingival symmetry, presence of occlusal wear, and history of orthodontic therapy to a clinical crown ratio of .90 or above.

The odds ratios, when relating the appearance of gingival excess with a ratio above .80, were OR = 79 (central incisor), 14 (lateral incisor), and 6 (canine). The odds ratio, when relating the appearance of gingival excess with a ratio above .90, were OR = 9 (central incisor), 17 (lateral incisor), 6 (canine).

Clinical length, clinical width, and clinical W: L ratio was compared to the subjective appearance of gingival excess in the maxillary central incisors, lateral incisors, and canines (**Table 6**). The mean clinical crown length was less when the subject had a subjective appearance of gingival excess. Subjects with a clinical crown length equal to or less than 8.86 mm (centrals), 7.39 mm (laterals), and 8.46 mm (canines) were more likely to be classified as having gingival excess. When the subject had a clinical crown length of 10.02 mm (centrals), 8.48 mm (laterals), and 9.68 mm (canines), the subject was less likely to be classified as having the appearance of gingival excess. Subjects with a clinical crown width

equal to or less than 8.51 mm (centrals), 6.59 mm (laterals), and 7.69 mm (canines) were more likely to be classified as having an appearance of gingival excess. Clinical crown width of 8.53 mm (centrals), 6.68 mm (laterals), and 7.69 mm (canines) were not related to the appearance of gingival excess. Subjects with a clinical W: L ratio of .97 (centrals), .90 (laterals), and .91 (canines) were more likely to be classified as having the appearance of gingival excess. Subjects with a clinical W: L ratio of .86 (centrals), .79 (laterals), and .80 (canines) were more likely to be classified as not having the appearance of gingival excess. Other variables such as biotype, appearance of gingival symmetry, presence of occlusal/incisal wear, and history of orthodontic therapy were not related to the clinical length, width, and/or W: L ratio according to the current analysis.

## Discussion

Altered passive eruption is a condition that can result in the appearance of a “gummy smile” which, according to previous research, is deemed unaesthetic. Studies have attempted to create an objective measurement for aesthetics, resulting in several smile proportion theories. One such theory, the RED proportion has been accepted by a majority of dentists and patients alike. This proportion has a clinical crown width: length ratio range of .66 to .80 as being aesthetic. Ratios above .80 results in the appearance of short, square teeth. While clinical width: length ratio plays an important part in the creation of an aesthetic smile, it is just a single aspect of an aesthetic smile. By determining the percentage of tooth types with a ratio above .80, this study reported the prevalence of altered passive eruption in a dental school population.

The results of the current study indicate that the average clinical W:L ratio (per tooth type) was greater than the accepted maximum ratio (.80) for ideal esthetics. A more recent North American study concluded that the mean clinical W:L ratio of the maxillary anterior teeth in 71 Caucasian subjects was 0.81<sup>32</sup>. These results are similar to Konikoff<sup>1</sup>, who found that the average clinical W:L ratio for maxillary central incisors ranged from .87-.88. The current study found the average ratio for maxillary central incisors to be .88. The current study also found that 83% of the subjects had central incisors that were greater than .80. According to Konikoff<sup>1</sup>, the percentage of the subjects that had central incisors with a ratio above .80 was 85-90% (pre-orthodontic treatment) and 61-71% (post-orthodontic therapy).



When examining the relationship between the appearance of gingival excess and clinical length, clinical width, and clinical W:L ratio by tooth type (**Table 6**) it was noted that in subjects where the ratios were greater than .90 (**Fig 1.**), the appearance of gingival excess was recorded. Central incisors, canines, and lateral incisor were less likely to be associated with a “gummy smile” when their clinical W:L ratios were .86, .80. and .79 respectively (**Fig. 2**). Based on the findings from the current study, it appears that a ratio of around .80 is indeed associated with an aesthetic smile. It should also be noted that 83% of central incisors in the current study had a clinical W:L ratio of above .80. So, do all the subjects that had a ratio above .80 need esthetic crown lengthening to achieve ideal esthetics, or are their other components to a smile that need to be considered? It is important to note that the subjects for this study were on average older than the subjects from Konikoff and co-workers’ study. That patient population was younger, and according to previous research the gingival margin of maxillary anterior teeth can shift up to age 16<sup>27</sup>. Since the average age of this study was around 26 years of age, one can assume that further shifting of the gingival margin will not be as significant as in a younger subject population. The clinical W:L ratio for these subjects is stable. Any further improvement to the smiles in subject population would come about by orthodontic, restorative, and/or periodontal therapy.

An important measurement was recording if the subject appeared to have gingival excess, or a “gummy smile”. Logistic regression analysis determined that there was statistically significant relationship between a clinical W:L of .80 and/or .90 and the appearance of a “gummy smile”. It appeared that the subjective impression of the “gummy smile” may be

related to the clinical W:L ratio, i.e. the examiner was more likely to note a “gummy smile” when the ratio exceeded .80 and/or .90. It should be noted that the opinion of whether the subject had the appearance of a “gummy smile” was carried out by one examiner. Still, it is interesting that there was a relationship between the subjective appearance of a gummy smile and the clinical W:L ratio when it was greater than .80 and .90. This is similar to the findings in previous research<sup>11</sup>. This analysis suggests that esthetic crown lengthening with the aim of achieving a clinical W:L ratio of .66-.80 might create a subjective appearance of an aesthetic smile versus a “gummy smile”.

Further analysis also brings up other variables that can affect the appearance of the smile. ANOVA suggests that gender and tooth type have a statistically significant effect on the clinical W:L ratio, with females having a higher ratio than males and 2<sup>nd</sup> premolar clinical W:L ratio > central incisor clinical W:L ratio > 1<sup>st</sup> premolar clinical W:L ratio > canine clinical W:L ratio > lateral incisor clinical W:L ratio. This is similar to the results of another study<sup>32</sup> that concluded that gender had an effect on clinical W: L ratio, particularly for the canine. The current study was not designed to compare individual tooth type ratios between genders. These findings bring up other questions. Do females have a different “ideal” clinical W: L than males? Do specific teeth have greater effect on the appearance of a “gummy smile” than others? Does a central incisor (which brings balance and stability to a smile<sup>14</sup>) with a clinical crown W: L ratio greater than .80 create the appearance of a gummy smile to a greater extent than the clinical W: L ratio of canine or a lateral incisor?

When breaking down the ratio into separate measurements (clinical length and clinical width), the current study found differences between these measurements and the average normal measurements. The clinical length by tooth type was shorter than the anatomical normal length, ranging 0.5-1.5 mm shorter. **Table 5** shows normal anatomical tooth dimensions. One explanation for the tooth length being on average smaller than the lengths described in Wheeler<sup>7</sup> could be that those measurements fail to consider the average gingival attachment of 0.5-2 mm<sup>8</sup>. If this average gingival attachment value is added to the current study length measurements, the current clinical length averages resemble those reported as being normal anatomical averages. Biotype (thin>thick), gender (M>F), and tooth type also played a role in clinical tooth length. The width by tooth type did not vary as dramatically as the length did because clinical width was measured contact to contact, and no contact was covered by soft tissue in the present study. Clinical width was affected by gender (M>F) and tooth type only (central incisor > canine > 1<sup>st</sup> premolar > 2<sup>nd</sup> premolar > lateral incisor). Other variables did not have a statistically significant effect. There have been significant gender differences reported with regards to tooth anatomy<sup>13,32</sup>. The present findings regarding the relationship of tooth length and width with gender are in agreement to those of other studies.

Another finding in the current study was that the average papillary height per tooth type ranged from 3.70 mm for the 2<sup>nd</sup> premolars to 4.60 mm for the central incisors. Konikoff<sup>1</sup> reported that 83% of the teeth examined had a papillary height of less than 4.5-5 mm. This is in contrast with Townsend<sup>17</sup>, who reported an average of 4.5 to 5 mm of papillary height

to be ideal. Altered passive eruption can cause coronal displacement of soft tissue, allowing this soft tissue to be on a flatter portion of the crown. This results in a flatter, and thus shorter, scallop. Thus the average papillary height in the present study can possibly be explained by the higher than ideal clinical W: L ratio of the subject population.

Distance from the lateral incisor gingival zenith to the GAL was measured in the current study. A mean of 1.05 and 1.08 mm was reported for #7 and #10, respectively. This is comparable to the accepted ideal of 1-2 mm suggested by Ahmad<sup>15</sup>. In a previous study, Konikoff found that 85.2% of the laterals were in a proper relationship to the GAL. A possible complication was that this measurement was done solely on casts without the aid of an interpupillary line. This could have possibly resulted in a GAL with an unusual morphology, thereby affecting final measurements.

One last aspect that is mentioned to be an important component of a smile is gingival symmetry<sup>33</sup>. In the current study, 93% of the subjects appeared to have gingival symmetry (**Fig 3**). This is contrasted by a previous study that found that 61-68% of the population had a gingival *asymmetry* (**Fig 4**). The reason for this discrepancy was the way symmetry was measured in the studies. The current study measured symmetry by clinical examination, comparing the GAL on both sides of the maxillary arch. Symmetry was not verified on casts. It is undetermined whether this lack of asymmetry was due to operator position or some other source. According to the present study's analysis, it appeared that symmetry was not related to the number of times that the clinical W:L ratio exceeded .80

and/or .90. Symmetry had no significant relationship with either clinical length, clinical width, or clinical W:L ratio according to ANOVA.

This study focused on a specific part of an aesthetic smile. Other parts, such as location of the CEJ, location of incisal edge, and lip line position were not evaluated. The issue of symmetry would have been best studied by evaluating photos of subjects with and without altered passive eruption, so that the clinician can establish a interpupillary line and compare this with the GAL. From there, accurate observations could be made of the presence or absence of gingival symmetry.

This study presents some important findings with regards to prevalence of altered passive eruption and smile esthetics. Based on the clinical W:L of central incisors, 83% of the subjects did not fall within the ideal ratio range of .66-80. Indeed, when subjectively evaluating the appearance of gingival excess for each subject, it was found that subjects who exceeded the clinical W: L ratio of .80 and/or .90 were more likely to have been classified as having the appearance of gingival excess. One way of achieving ideal W: L ratio would be in the form of esthetic crown lengthening. This information will aid dental clinicians in providing the most aesthetic results possible for their patients.

## Conclusion

83% of the subject population had central incisors that displayed altered passive eruption, according to the present study's definition (a clinical W: L ratio greater than .80). Subjects who exceeded the clinical W: L ratio of .80 and/or .90 was more likely to have been classified as having the appearance of gingival excess. The mean clinical length was on average 0.5-1.5 mm shorter than ideal length, while the mean clinical width was similar to ideal width. The average clinical W: L for central incisors was .88, compared to an ideal clinical W: L ratio of .80. Clinical crown length was affected by gender, biotype and tooth type. Clinical crown width and clinical W: L ratio was affected by gender and tooth type.

The average distance from the gingival zenith of the lateral incisor to the GAL ranged from 1.05-1.08 mm. The papillary height range was 3.88-4.60 mm. 93% of the subject population had a subjective appearance of gingival symmetry. The appearance of gingival symmetry was not related to the clinical W: L ratio, however this finding may not be accurate due the way symmetry was measured in this study.

## **Tables**

**Table 1.**

Distribution of Subject Demographic Variables: Gender, Race, History of Orthodontic Treatment, Presence of Parafunctional Habits, Presence of Incisal/Occlusal Wear, Gingival Biotype, Appearance of Gingival Symmetry.

<b>Gender</b>	<b>N</b>	<b>Percentage</b>
Male	61	61%
<b>Race</b>		
African American	2	2%
Asian	16	16%
Caucasian	72	72%
Hispanic	4	4%
Other	6	6%
<b>Orthodontic Treatment</b>		
Yes	61	61%
<b>Parafunctional Habits</b>		
Yes	67	67%
<b>Occlusal/Incisal Wear</b>		
Yes	95	95%
<b>Biotype</b>		
Thick	71	71%
Thin	29	29%
<b>Appearance of Symmetry</b>		
Yes	93	93%
<b>Appearance of Gingival Excess</b>		
Yes	20	20%

**Table 2.**

Periodontal measurements and indices according to tooth type: Pocket Dept (PD), Clinical Attachment Loss (CAL), Bleeding on Probing (BOP), Periodontal Index (PI), Gingival Index (GI).

	2 <sup>nd</sup> Premolar		1 <sup>st</sup> premolar		Canine		Lateral Incisor		Central Incisor	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PD (mm)	<b>1.95</b>	0.70	<b>1.92</b>	0.66	<b>1.82</b>	0.60	<b>1.78</b>	0.55	<b>1.79</b>	0.56
CAL (mm)	<b>0.04</b>	0.25	<b>0.07</b>	0.34	<b>0.03</b>	0.19	<b>0.02</b>	0.13	<b>0.04</b>	0.23
BOP	<b>0.02</b>	0.13	<b>0.03</b>	0.17	<b>0.02</b>	0.13	<b>0.02</b>	0.13	<b>0.02</b>	0.15
PI	<b>0.37</b>	0.55	<b>0.58</b>	0.68	<b>0.82</b>	0.76	<b>0.78</b>	0.75	<b>0.86</b>	0.80
GI	<b>0.23</b>	0.43	<b>0.35</b>	0.49	<b>0.54</b>	0.57	<b>0.61</b>	0.59	<b>0.58</b>	0.57



**Table 3.**

Cast Measurements: Papillary Height (PH), Width, Length, Width:Length Ratio (W:L),

Percent Over Ideal Width: Length Ratio of .80.

	2 <sup>nd</sup> Premolar		1 <sup>st</sup> premolar		Canine		Lateral Incisor		Central Incisor	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PH (mm)	<b>3.70</b>	0.89	<b>3.94</b>	0.98	<b>4.38</b>	0.94	<b>3.88</b>	1.01	<b>4.60</b>	1.04
Width (mm)	<b>6.42</b>	0.48	<b>6.81</b>	0.46	<b>7.69</b>	0.53	<b>6.66</b>	0.58	<b>8.53</b>	0.57
Length (mm)	<b>6.99</b>	0.81	<b>8.08</b>	0.81	<b>9.44</b>	1.02	<b>8.27</b>	0.94	<b>9.79</b>	0.98
W:L	<b>0.93</b>	0.11	<b>0.85</b>	0.10	<b>0.82</b>	0.09	<b>0.81</b>	0.09	<b>0.88</b>	0.09
Percent over ideal W:L of .80	<b>0.89</b>	0.31	<b>0.71</b>	0.46	<b>0.59</b>	0.49	<b>0.54</b>	0.50	<b>0.83</b>	0.38

**Table 4.**

Distance from lateral incisor gingival zenith to GAL.

	Mean	SD
Tooth #7	<b>1.05</b>	0.55
Tooth #10	<b>1.08</b>	0.54

**Table 5.**

Normal clinical values for maxillary central incisors to maxillary second premolars.<sup>7</sup>

<b>Tooth</b>	<b>Cervico- Incisal/Occlusal Length of Crown (mm)</b>	<b>Length of Root (mm)</b>	<b>Mesiodistal Crown Diameter (mm)</b>	<b>Mesiodistal Cervical Diameter (mm)</b>
<b>Central Incisor</b>	10.5	13	8.5	7
<b>Lateral Incisor</b>	9	13	6.5	5
<b>Canine</b>	10	17	7.5	5.5
<b>1<sup>st</sup> Premolar</b>	8.5	14	7	5
<b>2<sup>nd</sup> Premolar</b>	8.5	14	7	5

**Table 6.**

Subjective Appearance of Maxillary Gingival Excess As Related to Clinical Crown Length, Clinical Crown Width, and Clinical Crown Width:Length Ratio.

			Length		Width		W:L	
			Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Arch Tooth	Appearance of Gingival Excess	N						
Central	No	160	<b>10.02</b>	0.87	<b>8.53</b>	0.59	<b>0.86</b>	0.07
	Yes	40	<b>8.86</b>	0.84	<b>8.51</b>	0.46	<b>0.97</b>	0.08
Lateral	No	160	<b>8.48</b>	0.81	<b>6.68</b>	0.56	<b>0.79</b>	0.08
	Yes	40	<b>7.39</b>	0.92	6.59	0.65	<b>0.90</b>	0.09
Canine	No	160	<b>9.68</b>	0.92	<b>7.69</b>	0.53	<b>0.80</b>	0.08
	Yes	40	<b>8.46</b>	0.78	<b>7.69</b>	0.55	<b>0.91</b>	0.08
1 <sup>st</sup> Premolar	No	160	<b>8.26</b>	0.75	<b>6.81</b>	0.45	<b>0.83</b>	0.09
	Yes	40	<b>7.39</b>	0.69	<b>6.82</b>	0.49	<b>0.93</b>	0.08
2 <sup>nd</sup> Premolar	No	160	<b>7.09</b>	0.81	<b>6.46</b>	0.48	<b>0.92</b>	0.12
	Yes	40	<b>6.61</b>	0.72	<b>6.28</b>	0.48	<b>0.96</b>	0.08

## **Figures**

**Fig. 1 Appearance of Gingival Excess**



**Fig. 2 Absence of Gingival Excess**



**Figure 3. Presence of Gingival Symmetry**



**Figure 4. Absence of Gingival Symmetry**





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### VITA

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